TOWARD AN ALTERNATIVE APPROACH FOR ROADING ORGANIZATIONS EMERGENCY MANAGEMENT TRAINING AND RESEARCH: EXERCISES OBSERVATION AND GAME-BASED SCENARIO SIMULATION

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ABSTRACT

Emergency management data can be scarce and biased due to response priorities, compiling processes and time spans between event occurrence and data collection. Such limitations are heavily associated with natural and man-made disasters been the most reliable sources of information for emergency management research. This paper presents a synergic method to collect data by observing and simulating emergencies. This combined approach originated from the need to have additional experiences to support research by not uniquely relying upon real events or big scale emergency simulations, which can be too sporadic and costly. Road organizations were defined as the main case study due to their vital role in emergency response and recovery. A five-step observation method and a game-base scenario simulation were designed and assessed. To do so, it was observed seven exercises in New Zealand and conducted pilot simulations with numerous volunteers. Data collected using the proposed method, indicated promising results to model extreme event decision-making as well as potentials to generate knowledge for decision support. The method has also shown opportunities to be applied as a cost efficient emergency management training tool due to low development and implementation costs.

INTRODUCTION

Direct and indirect impacts from natural and man-made disasters have challenged both industry and academia in recent decades. The 1994 Northridge Earthquake (USA), the 1995 Kobe Earthquake (Japan), the 2004 Sumatra Earthquake and Tsunami (Asia), the 9/11 Terrorist Attacks (USA) and 2005's Hurricane Katrina (USA) are just few events that affected societies world-wide. Natural disasters alone accounted for 535,000 deaths and US$ 684 billion in losses in the last decade (1).

Complexities in managing emergency events have already been reported by many authors using experiences acquired from real or simulated disasters (2 – 4). However, numerous research attempts (e.g. decision-making modeling, organizational planning, decision support tools development) were limited due to data limitations and/or lack of alternative sources of information.

Although great advances have already been achieved and technologies developed, research are still restricted due to real events and big scale simulations been almost the exclusive source of information. Collecting data at real grounds after a disaster implies in numerous challenges, such as local culture and priorities, data collection and storage methods (i.e. data quality and accuracy), government policies, commercial sensitiveness regulations. Authors agree that emergency response data is scarce and emergency simulations alone can be potentially unrealistic due to scenarios been hard to be properly emulated (5).

Recent industry and academic endeavors indicate positive synergy between two possible research approaches: i) exercises observation and ii) small scale emergency simulation (6). Research efforts have shown prominent results for emergency simulation. For instance, game simulations have been used for training in the military context (7). Thus, exercise simulations practice the "use of information to alleviate the challenges in urban warfare scenarios" to ultimately understand "issues surrounding information requirement and usage, sense making, and command and control" (7). Additionally, simulations have been used to evaluate decision support tools (8) and to investigate decision-making activities (9).

Such successful achievements have produced momentum for emergency management research. Both industry and academia are now investing considerable resources and efforts to develop concepts and procedures in order to reduce disasters' impacts and to better understand particular simulation techniques for emergency management. Response manuals, policies, information technologies and training techniques are just few outcomes from these endeavors. Following this tendency, New Zealand authorities have been investing in emergency exercises and training as well as funding for emergency management research. Exercises have become a common practice in the country. They range from local to national activities and have demonstrated great capability to emulate complexities observed in real events.

Building upon the observation of seven emergency exercises in New Zealand, we have proposed a synergic method to collect data by rigorously observing and simulating emergencies. The method was assessed after observing seven exercises in New Zealand and conducting pilot game simulations with numerous volunteers. Experiences indicated future opportunities to use the proposed method to conduct decision-making analyses. Finally, the game-based scenario simulation has proven to reduce simulation costs due to its small scale and to be able to emulate realistic emergency environments to be used for both research and training.

This paper comprises four sections. It presents theories from the scientific literature, the proposed observation / game-based framework and a brief analysis of pilot surveys conducted in order to assess the method. After this introduction, the second section briefly describes Naturalistic Observation and Gaming for Survey techniques used to design the research method. The data collection framework is specified in the third section, in which a general observation process is proposed along with a specific game scenario for roading organizations. The last section presents the results achieved after exhaustively assess the framework as well as intended future research steps.

THEORETICAL BACKGROUND: OBSERVATION AND GAME SIMULATION TECHNIQUES

This section briefly presents the literature review conducted for this research. Both observation and game simulation techniques are discussed in order to support the proposal of the combined observation and simulation method in the next section.

Naturalistic Observation

It is a technique commonly used by psychologists and behavioral scientists. It involves observing subjects in natural settings in "an unobtrusive way, which aims at collecting behavioral data in real-life situations as opposed to laboratory or controlled settings" (10, 11). A naturalistic observation process aims at the study of events and people as they naturally occur and react, respectively.

A Naturalistic Observation case study can be overt (participants aware of observation) or covert (participants not aware of observation). The method choice depends on specific research objectives; however, regardless the approach taken, it is strictly necessary to not intervene on the environment so bias is not created.

Gaming for Survey

The history of gaming can be tracked back in 1962, when a PDP-1 (Programmed Data Processor-1) was used to develop simulations at the Massachusetts Institute of Technology (12). Although its initial success, gaming simulations have not had a formal branch in science until the eights when Ellington *et al.* (13) published a book titled "Games and Simulations in Science Education". The authors identified the inexistence of formal basic texts and source books on science-based gaming as a gap, which impaired its development. This fact motivated researchers to review early developments and to identify and investigate a series of concepts and applications of gaming for research.

In this backdrop, numerous simulations in forms of cards and board games were reported between 1970 and 1975 (13). It was also the time when computer-based simulations became accessible for many universities and large organizations, e.g. IBM Research Centre (14). In the next two decades (1980s and 1990s) concepts of gaming for both entertainment and surveying were consistently developed and evolved. For instance, the well known game SimCity 2000 (firstly released on 1993), originated from serious studies about urban dynamics (15), culminated into a very popular entertainment and teaching tool (16). Other successful teaching and learning experiences have also stimulated researchers and practitioners to invest efforts and resources into game simulation for research.

From the 90s to date, computers have created sophisticated opportunities due to great flexibility and data handling capacity offered by hardware and software. Cognitive skills such as problem-solving and decision-making have been consistently practiced in many game simulations. In recent years, authors have developed concepts and reported experiences in using complex simulations for the study of decision-making and decision-making support during stress laden situations (17 – 19).

Regardless field of application or approach taken, game simulations have shown a fascinating capacity to emulate scenarios and practice real-life situations. Ellington *et al.* (13) conclude that game and simulations are useful for research as they can be highly versatile and flexible in oppose to real situations and it can achieve positive transfer of learning, i.e. development of abilities and skills to be applied in real situations (20).

Three formal concepts lay the foundations for game simulations: i) Game, ii) Simulation and iii) Case Study. In general terms, games are defined as contests among adversaries operating under constraints (rules) towards a given objective. Simulations are “operating representations of contextual features of realities” (13). Finally, case studies are in-depth studies of a particular event, problem or situation (21), which aim at the generalization of knowledge gained (22).

The three concepts abovementioned are commonly considered in developing simulations. In general terms, simulations aim at replicating a real ongoing situation (Simulation) under specific pre-defined rules (Game) so a particular event, problem or situation can be in-depth studied (Case Study). Hence, designed research questions can be answered (meant to be the game’s objectives).

DATA COLLECTION FRAMEWORK: EXERCISES OBSERVATION AND GAME-BASED SCENARIO SIMULATION

A two stage data collection method was developed aiming at the observation of emergency exercises and emergency scenario simulation. The first stage is performed under naturalistic observational techniques and the latter through a specifically designed game-based simulation for the case of roading organizations.

Observation Method

A five-step observation method is proposed taking advantage of popular emergency exercises practices. It aims at identifying and observing emergency training endeavors as follows:

- Step 1: Search appropriate upcoming emergency exercises;
- Step 2: Once an exercise is identified, contact organizations responsible for organizing the exercise in order to check the possibility to take part as observers;
- Step 3: If the participation is authorized, get familiar with dynamics, individual participants, objectives, major players, scenario and injects;
- Step 4: To arrange / define necessary surveying consumables / processes and conduct the exercise observation focusing on steps given in Table 1; and
- Step 5: To report the experience to fellow researchers in order to exchange and collect alternative points of view.

TABLE 1 Observation Activities and Expected Analyses for the Observation of Extreme Events Decision Making

<table>
<tr><th colspan="2">Step</th><th>Activities and Expected Outcomes</th></tr>
<tr><td>1</td><td rowspan="2">Knowledge Elicitation</td><td>Observation of decision-making process during real and simulated extreme events and tracing of the decision making stories.
Qualitative assessment of tangible/intangible vulnerabilities affecting the decision making.</td></tr>
<tr><td>2</td><td>Debriefs and in-depth interviews with subject matter experts following real and simulated events. Identification of the cognitive elements that underlie decision making.</td></tr>
<tr><td>3</td><td>Analysis and knowledge representation</td><td>Extracting meanings from the acquired data and information and displaying the results.</td></tr>
</table>

Critical observation activities from Step 4 were defined upon elements identified in the literature that distinguish decision-making processes applied in emergency situations. For all three identified elements (namely, information sharing, decision-making expertise and experience and situation awareness), a reference scheme was defined. The Defence Command and Control Research Program (CCRP), used in USA for professional military education (23), groups decision-making into four aspects (e.g. operational, technical, analytical, and educational), which ultimately operate under three domains: i) physical, ii) information, iii) cognitive and iv) social. A complementarily theoretical background along with numerous case studies applications can be found in Ferreira *et al.* (24).

Finally, a practical complexity needs to be addressed when applying the observation method: commercial sensitiveness. In this context, anonymous reporting and names suppression shall always be ensured in order to facilitate approval for observation.

Occasionally, a Re-Enactment process is performed in order to replicate the exercise with researchers not familiar with the scenario. It ultimately aims at increasing data availability and broadening experiences.

Game-Based Scenario Simulation Method

A specific game simulation was designed for the case of roading organizations due to our intended case study. Design protocols were defined accordingly to requirements identified from the literature review conducted as shown in Figure 1.

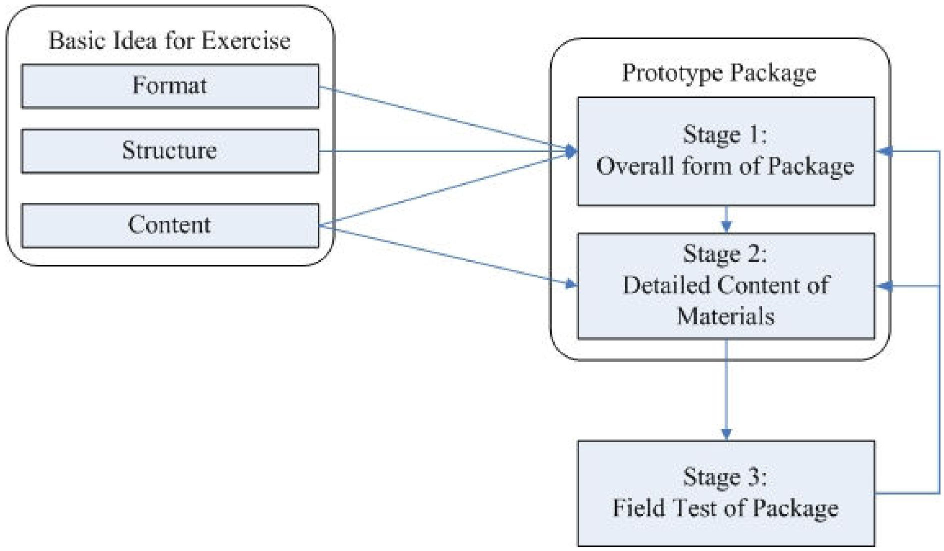

FIGURE 1 Converting a Basic Game Idea into a Viable Package (13)

Aiming at designing a viable game package for the case of State Highway Organizations, we firstly defined format, structure and content. A board game format was chosen due to ease and quick graphical development needs. The structure accounted for an emergency simulation, in which an emergency scenario is presented to the player through a series of injects reporting current events. This is a similar structure to the one used at emergency exercises, i.e. scenario information is provided to participants to ultimately build a complex and interdependent sets of events. Simulation content comprises a 7.2 Earthquake in the Richter Scale affecting a hypothetical city of 150,000 inhabitants featuring common urban systems (e.g. central business district, residential suburbia, commercial areas, industrial area, road network system, railway line).

With the exercise's basic idea set up, we have defined initial prototype package descriptions. In this context, general requirements were drawn to meet structure needs and content representation accordingly to the desired game-board format. The initial overall Prototype Package form (Stage 1) was defined according to the following seven specifications:

- Representation of transport networks such as roading and rail due to our intended focus on transportation issues arisen from emergency events occurrences;
- Presentation of ordinary urban regions, such as including hospital, parks, airport, commercial and administrational centers, central business district, residential areas and etc;
- Ease readable board game;
- Injects in hardcopy format;
- Physical resources numerically represented in number of available units. No type specification (e.g. diggers, trucks, temporary traffic management signage);
- Time limitations to perform response in order to simulate stress and pressures common to emergencies; and
- Exercise time length limited to a range of 25 to 35 minutes plus interview time to encourage participation.

At practical levels, Prototype's design requirements helped to shape final procedural ideas for the game simulation as well as to refine the content and define the list of materials needed (Stage 2). Generally speaking, the intended game would present the user with a board representing an urban area, a specific number of physical resources to be managed (i.e. deployed) and a time limitation enforcement method. The simulation would be operationalized by presenting a series of injects to the participant at the beginning of each simulated response day (i.e. 7 minutes). Finally, the participant could enquire the exercise controller about any additional information not provided by the injects (or specific scenario information). However, additional information would only be made available according to the scenario's progress and queries performed.

Hence, the Prototype Package (Stages 1 and 2) can be summarized as an emergency scenario simulation containing a board game, resources availability and injects. Board game, resources and hardcopy injects are the materials needed to run the simulation.

Following the process proposed in Figure 1, we performed initial field tests aiming at refining the Game-Base Scenario Simulation Package. A first game version (i.e. board, scenario / injects, simulation procedures) was exhaustively tested with support from volunteers. Testing routines were set up based on simple assessment procedures by making use of fellow researchers. Thus, a number of participants (initially unaware of this research endeavor) were invited to "play" the game and report his / her impressions, feelings and suggestions for improvements. Testing was performed at two different levels and involved five people. Great advances at both graphical design and scenario simulation were achieved after such testing activities. The following paragraphs describe the final game simulation version, including its materials and processes.

The simulation was graphically designed using simple tools to create the board game (Figure 2). The board is associated with a set of events (i.e. injects), which ultimately define the emergency scenario (further described in this subsection). Injects aim to dynamically present data and information about the extreme event under simulation; therefore, create a complex and interdependent set of events to be managed. Both board and injects were parallely developed and checked in order to avoid inconsistencies.

A few simple rules were defined to run the simulation aiming at simplicity. Thus, the participant should not make use of any external resource (e.g. computer, response manual, maps) or ask for support from work colleagues during the simulation. Information is only available through hardcopy injects given to the participant at the beginning of each response day or by directly asking the exercise controller. In the latter case, a query should be directed to the exercise controller with a clear message about the desired information. Additional information can be provided or not accordingly to the flow of events.

Following design descriptions defined at Stage 1, the experiment was limited to a 25 / 35 minute period. It has been assumed a good time length to encourage participation according to impressions taken from the pilot simulations and suggestions made by volunteers involved in the trials. Within this time frame and scenario particulars, we have defined the number of resources movements (or deployment) to five times. Each deployment finally represents a response day, which should about seven minutes. If resources are not moved after this given time, it is understood that the participant has decided for a *status quo* situation.

Finally, pre-event decision-making planning was intended to be captured by asking the participant to fill in the Prioritization Matrix (Table 2). Data collected using such tool shall be analyzed in parallel with actual resources deployment performed during the simulation. The matrix is to be filled before the simulation in order to avoid bias. The participant has to simply fill the blank cells using the given scale. Such technique (multi-criteria) is well known and developed in the scientific field and can provide a number of indicators to the analyst, such as consistency ratio, conflicting priorities, relative priorities and etc.

TABLE 2 Prioritization Matrix.

Items "i" / Items "j"	Support Immediate Rescue	Protect Private Property	Support Lifelines	Protect Economy	Protect Environment	Enable Support from other Areas	Repair Key Infrastructure	Facilitate Accessibility Between Communities
Support Immediate Rescue	1.00							
Protect Private Property		1.00						
Support Lifelines			1.00					
Protect Economy				1.00				
Protect Environment					1.00			
Enable Support from other Areas						1.00		
Repair Key Infrastructure							1.00	
Facilitate Accessibility Between Communities								1.00

Note: Scale to be used

Item displayed on rows of equal or more importance than items on columns	Item displayed on columns of equal or more importance than items on rows
1: Items "i" and "j" are of equal importance.	**1: Items "j" and "i" are of equal importance.**
3: Item "i" is weakly more important (or better) than "j".	**1/3: Item "j" is weakly more important (or better) than "i".**
5: Item "i" is strongly more important (or better) than "j".	**1/5: Item "j" is strongly more important (or better) than "i".**
7: Item "i" is very strongly more important (or better) than "j".	**1/7: Item "j" is very strongly more important (or better) than "i".**
9: Item "i" is absolutely more important (or better) than "j".	**1/9: Item "j" is absolutely more important (or better) than "i".**
2, 4, 6 and 8: are intermediate values.	**1/2, 1/4, 1/6 and 1/8: are intermediate values.**

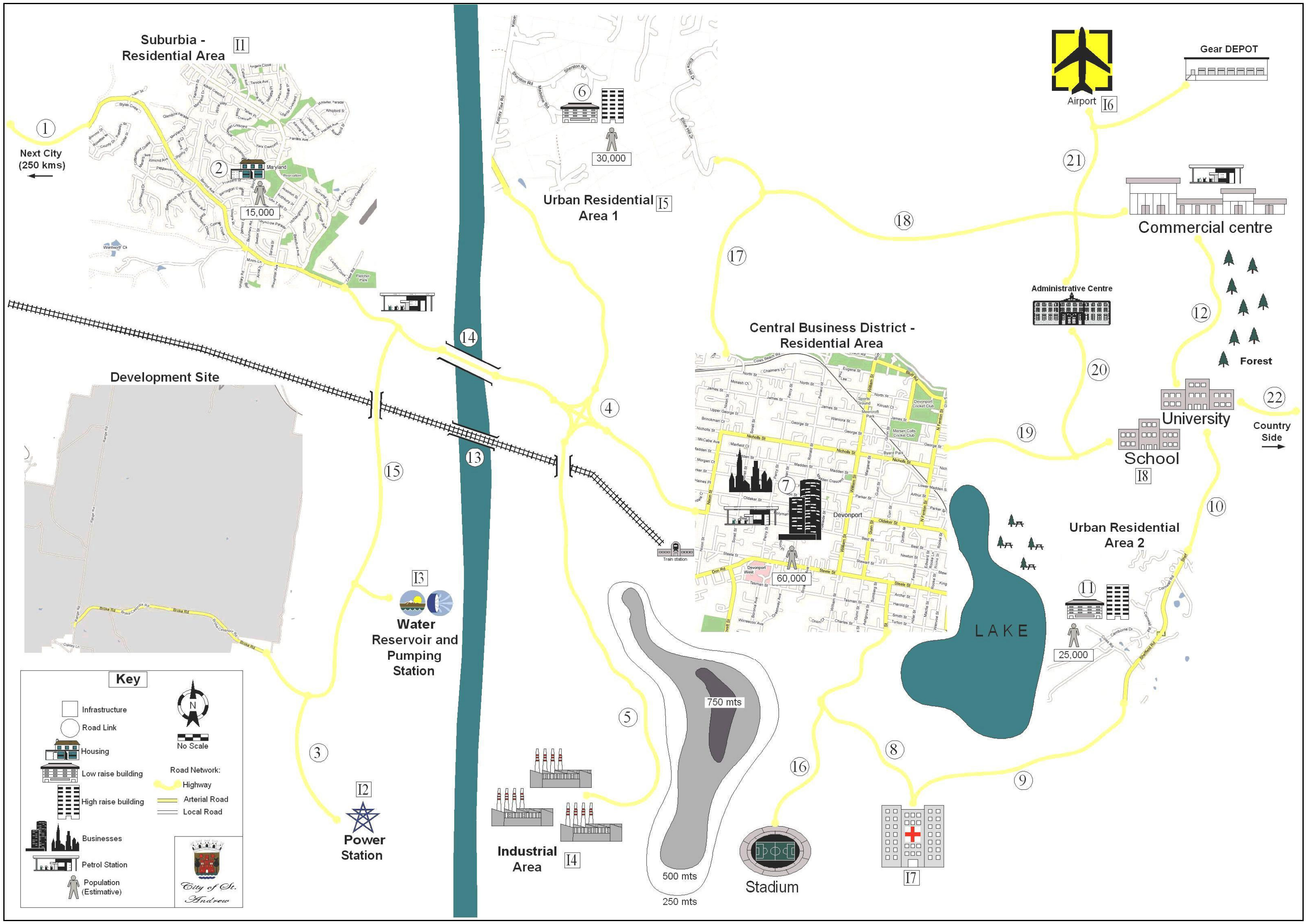

FIGURE 2 Board Game

During the simulation, data is collected by observing the number of resources deployed to each road link and directly enquiring the participant his/her motivations for such decisions. Thus, after the given time of seven minutes, the number of resources deployed to each road asset and the participant's statements are recorded so both quantitative and qualitative data are available for future analyses. Upon the completion of the simulation, a semi-structured interview is conducted aiming at gathering final information on participant's general decision planning and decision-making.

The proposed earthquake scenario evolves similarly to a real event. Thus, only general situations are provided to participants in the first day, while specific information (e.g. damage, affected people, resource needs) are made available on subsequent days. It simulates an evolving event, in which infrastructures' assessments, lifelines situation reports, Civil Defence response operations among others, provide further specific information as time elapse.

As initially defined, the scenario develops over a five-day period after a major Earthquake in a hypothetical urban region. The event affects a city of around 150,000 people creating damage to roading systems, buildings / houses, businesses, airport, industries etc. According to game rules, additional information can be acquired depending on the participant's queries towards the exercise controller. However, all necessary information to proceed with response is made available through injects given to participants during the simulation. The information to be provided for each response day is described as follows. Please refer to Figure 2 (board game) to better understand the scenario's evolution and find damage location:

- Day One – superficial damage information about major transportation infrastructures is obtained from various sources. For instance, the road bridge over the river (road link 14) and the interchange (road link 4) are only reported damaged without any additional information. Response priorities are also established and circulated among response organizations by the Ministry of Civil Defence and Emergency Management. The main challenges refer to balance priorities among the key road links (e.g. external access and main bridge over the river) and the Central Business District (CBD) local roads as well as to draw a response plan without specific information about damage in some many areas;
- Day Two – building upon Day One events, asset damage information is updated. The information provided originates from formal assessments conducted in the first day as well as public information collected and confirmed by the Civil Defence. At this stage, with an increased volume of damage information, the challenge regards in meeting the most immediate needs considering resources availability. Hence, the initial designed response plan might need to be restructured according to a more specific situation drawn by precise information. Finally, two injects (immediate need to have access to the power station and increasing traffic flow at the damaged bridge over the river) are provided in order to create confusion and add new complexities to the decision maker;
- Day Three – specific damage information on numerous transportation infrastructures are given. It ultimately creates a very complex decision-making environment with many conflicting priorities (e.g. needs from the hospital, airport, industries, river contamination) and limited resources availability. The imminent collapse of a bridge poses a great issue to be managed in order to keep

the intended response plan as it demands many resources and an immediate response. Problems with water contamination and need to arrange alternative supply increases the scenario complexity, which is also built up form the previous day;

- Day Four – the scenario remains similar to Day Three and the only new information is a phone call from field personnel reporting chaos and traffic congestion at the Residential Area 1. A media update to TV regarding current response efforts and future plans is also required. Although not much information is given, the participant is still overwhelmed as lack of resources continues to be experienced throughout the city; and
- Day Five – similarly to day four, not much is added in terms of damage assessment and network operationability. A series of fax communications from numerous organizations (e.g. Railway Company, contractors and consultancies) are given to the participant. The intention is to simulate the latter stages on response when most of damage information has already been collected and information overload begins to happen.

FRAMEWORK ASSESSEMENT AND NEXT RESEARCH STEPS

The proposed data collection framework was tested over a long period of time in New Zealand. Emergency exercises have been under observation since June 2007 and the game development and test began at mid 2008. Researchers, roading controlling authorities, consultants and contractors were involved at both observations and game simulation development by providing valuable comments for improvements.

Data collected from observations have indicated potential contribution towards the understanding of general emergency management processes. Although specifics about emergency activities could not be identified, participants' engagement created complex and realistic emergency environments. Numerous learning opportunities originated from these experiences that ultimately contributed to acquire vast knowledge about organizational emergency management.

However, the exclusive observation of exercises observation could not suffice data needs due to the high complexity of emergency operations, scale of exercises and intrinsic method's limitation. At numerous instances, information was lost as actions took place at different rooms and within many groups (e.g. logistics, intelligence, communications). Additionally, some decisions could not be properly observed as participants and their respective teams did not clearly state their actions.

In this context, a specific game-based scenario simulation was developed in order to propose a new and complete research method. In the controlled environment created by the game simulation, specific data could be collected; therefore, decision-making concepts and models developed.

Initial field tests confirmed the synergic approach using both exercise observations and game simulations. Results indicated potential contributions to research endeavors for academia and a cost-efficient training tool for industry and government. In the latter case, the game simulation can be used for ongoing training without the need to engage whole organizations as well as investing too much financial resources in developing scenarios and organizing an event.

A follow up research reported in Ferreira *et al.* (24) targeted the development of a specific data analysis methodology to take opportunity of data collected in the observation of seven emergency exercises NZ and twelve game simulations conducted in New Zealand. The research process has supported a better understanding of extreme events decision-making, which is intended to culminate in the proposal of a decision support system for emergency management within roading organizations.

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REFERENCES

(1) International Federation of Red Cross and Red Crescent Societies. World Disasters Report: Focus on Reducing Risk. *Bloomfield, CT, Kumarian Press*, 2002.

(2) Mendonça, D., E. E. Lee II and W. A. William. Impact of the 2001 World Trade Center Attack on Critical Interdependent Systems. *2004 IEEE Systems, Man and Cybernetics (IEEE-SMC) Conference*, 2004. The Hague, The Netherlands.

(3) West, T., S. Miller, T. Zdunek, K. McKibben, R. Paul and D. Albright. Intergovernmental Cooperation in Benchmarking a Local Government Continuity-of-Operations Exercise. *Transportation Research Record*: Journal of the Transportation Research Board. Volume 2041 / 2008. DOI 10.3141/2041-02.

(4) Ballard, A. J. Traffic Operations for Hurricane Evacuation. *Transportation Research Record*: Journal of the Transportation Research Board. Volume 2035 / 2007. DOI 10.3141/2035-22.

(5) Barker, K. and Y. Y. Haimes. Assessing Uncertainty in Extreme Events: Applications to Risk-Based Decision Making in Interdependent Infrastructures Sector. *Reliability Engineering and System Safety 94*, 2009, pp. 819-829.

(6) ResOrgs. Resilient Organisations Research Programme. Department of Civil and Natural Resources Engineering. University of Canterbury. Christchurch, New Zealand. http://www.resorgs.org.nz/index.shtml. Accessed July 15, 2009.

(6) Fong, G. Adapting COTS games for military experimentation. Defence Science & Technology Agency, Singapore. *Simulation & Gaming*, 2006, Vol. 37, No. 4, 452-465 (2006). DOI: 10.1177/1046878106291670.

(8) Belardo, S. and W. A. Wallace. "Gaming" as a means for evaluating decision support systems for emergency management response", in Sullivan, J., Newkirk, R. (Eds). *Simulation in Emergency Management and Technology*, Society for Computer Simulation, 1989, La Jolla, CA, pp.113-7.

(9) Prohaska, C. R. and E. J. Frank. Using Simulations to Investigate Management Decision Making. *Simulation & Gaming*, 1990, Vol. 21, No. 1, 48-58 (1990) DOI: 10.1177/1046878190211004.

(10) Naturalistic Observation. http://social.jrank.org/pages/437/Naturalistic-Observation.html. Accessed July 18, 2009.

(11) Angrosino, M. V.. Naturalistic Observation. *Left Coast Press*, 2007. ISBN 1598740598, 9781598740592.
(12) PDP-1 Restoration Project. Computer History Museum. http://pdp-1.computerhistory.org/pdp-1/index.php?f=theme&s=3&ss=7. Accessed June 15, 2009.
(13) Ellington, H., E. Addinall and F. Percival. Games and Simulation in Science Education. *Kogan Page*, 1981, London / Nichols Publishing Company, 1981, New York. ISBN 0-85038-338-2.
(14) Peterson, T. I. and P. N. Wahi. Interactive Computer-based Game for Decision Making in Ecology. *IBM J. Res. Develop*, March 1972.
(15) Peschon, J., L. Isakson and B. Tyler. The Growth, Accretion, and Decay of Cities. *Technology and Society Technical Expertise and Public Decisions*, 1996. Pp. 301-310. Princeton, NJ, USA. ISBN: 0-7803-3345-4
(16) Adams, P. C.. Teaching and Learning with Sim City 2000. *Journal of Geography 97*: 47-55, 1998. National Council for Geography Education©.
(17) Power, D. J. How can simulation be used for decision support? DSS News, Vol. 4, No. 14, July 6, 2003.
(18) Power, D. J. What can DSS designers learn from video games? DSS News, Vol. 6, No. 24, November 6, 2005.
(19) Mendonça, D., G. E. Beroggi and W. A. Wallace. Assessing Group Decision Support Systems for Emergency Response Using Gaming Simulation. *Safety Science*, 2006, 44(6) 523-535.
(20) Gagné, R. M. The Conditions of Learning (2nd Edition). *Holt, Rhinehart and Winston*, 1970, London.
(21) Walker, M. The Use of Case Studies. *Education in Chemistry*, 1974, 11 2:58.
(22) Van Wagner, K. What is a Case Study? About.com: Psychology. http://psychology.about.com/od/cindex/g/casestudy.htm. Accessed June 8, 2009.
(23) Cheah M., C. Ngoh, G. Fong and E. Toh. NWC in Action – Experimentation within a Distributed and Integrated Command Environment. *Proceedings of 12th International Command and Control Research and Technology Symposium*, 2000.
(24) Ferreira, F., A. Dantas, E. Seville and S. Giovinazzi. Organizational Operations Planning and Decision-making During Extreme Events: The New Zealand State Highway Organizations Case. *89th Annual Transportation Research Board Meeting*, Washington, DC, January 10-14, 2010, Washington, D.C.